Bio Inspired Robot

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***Abstract*—This report contains the conceptual design process and assembly of a bio inspired robot. This robot was designed to use servos controlled by an arduino to walk 4.9m autonomously across the test track and back. It had to have the ability to be disassembled and the movement had to be bio inspired. This robot was successful in walking across the test track and meeting the functional requirements.**

I. Introduction

For the third project in MMAE 232, I designed a bio inspired robot that walked 4.9m in one direction and back to the starting line. The robot was required to walk autonomously and be disassembled. While the initial design proved to be too weak, the stronger, improved design was successful in meeting the functional requirements (see Fig. 1).

II. Concept Generation and Evaluation

The initial step taken in the design process was to determine two animals or insects to use as inspiration for the movement of the robot. I chose an ant and a snail. The posture of each design was also identified before sketches were produced. Designs for each were sketched out after that, as well as the Hildebrand Gait plots and convex contact polygons for the movement of each design.

Along with an analysis of the movement, a torque analysis on the actuators was also required. To accomplish this, a mass for the assembled robot was estimated and used to determine the force that the servos would have to counteract to hold the robot up.

This design wasn't required to follow any size constraints, but there were some assembly constraints. ⅛" and ¼" MDF was provided for use as the body, but other materials were allowed as well. The whole robot had to have the ability to be disassembled. Glue and tape were not allowed to attach any electronics to the robot, so screws had to be used to fasten everything to the body of the robot.

Both designs were evaluated using a Pugh chart, shown in Table 1. It was determined that Design 1 was better, so that was chosen to be constructed.

III. Analysis

As mentioned in the concept generation and evaluation, a Hildebrand Gait plot and convex contact polygons were drawn for each design. These plots are shown in Fig. 2 and Fig. 3. The Hildebrand Gait plot was drawn to ensure that robot would have a sufficient amount of legs supporting it at all times and to give a visual representation of the movement. The convex contact polygons were drawn for each stage of the walking cycle to ensure the robot's center of mass was in a location where it would be stable. The contact polygons for the chosen design were always either a square or a triangle. Having six legs made it really easy for the robot to be statically stable along with designing the center of mass to be roughly in the center of it.

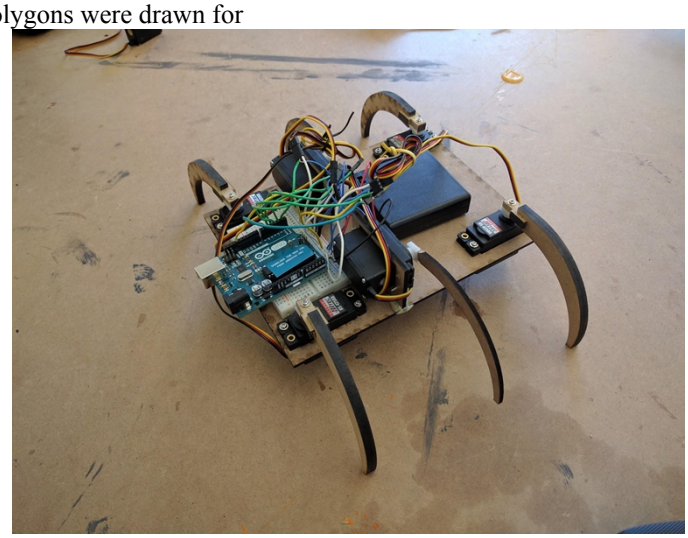

Fig. 1 Final assembled robot

Table 1	Baseline	Design 1 (Fig. 2)	Design 2 (Fig. 3)
Weight	0	+1	+2
Complexity	0	-1	0
Projected Rate of Success	0	+2	0
Stability	0	+2	+1
Total	N/A	+4	+3

IV. Experimental Results

The assembly and programming portions of the prototyping process definitely took the longest. Once all assembly and wiring was complete, the programming portion was pretty

straight forward since the movement was simple. The most time consuming part was tweaking the amount of movement in the servos and the orientation of

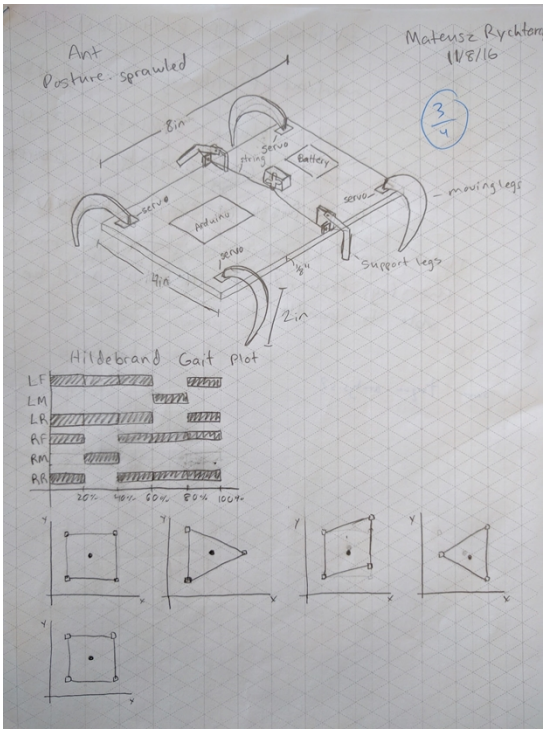

Fig. 2 Design 1 including Hildebrand Gait plot and convex contact polygons.

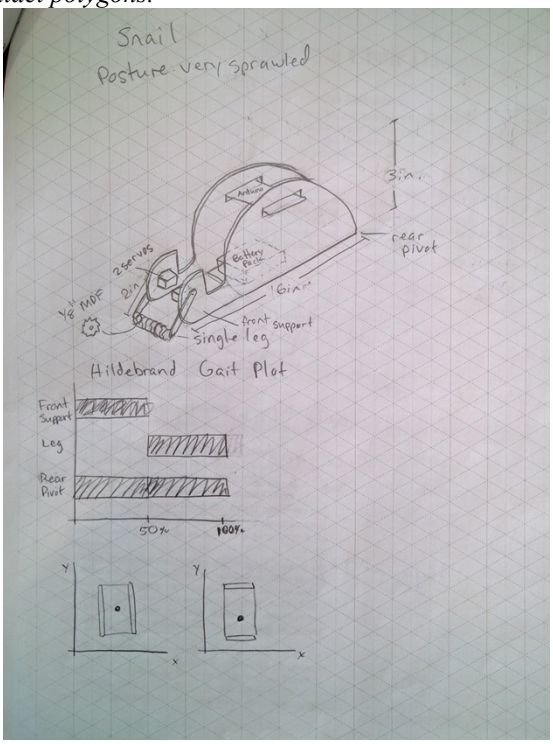

Fig. 3 Design 2 including Hildebrand Gait plot and convex contact polygons.

the servos since they couldn't move in a full 360 degree motion.

Weight was a concern for this design, so ⅛" MDF was used for the entire body and legs of the robot. It seemed that using ⅛" would be sufficient since only six servos were used, but there were some stress concentrations in the legs that were revealed very quickly after initial testing. The MDF began to bend where the legs were fastened to the servos, which cause the robot to drag itself on the ground eventually. Since it was clear that these legs weren't strong enough, new legs with the same design were design and cut using ¼" MDF instead. These proved to be much stronger, and didn't add too much weight since the legs still moved easily.

The final product ended up being very slow since the movement had many gaits which did not produce much movement per cycle. Although it was slow, the robot did meet the functional requirements of autonomously walking 4.9m back and forth across the test track.

V. Discussion

The bio inspired design process turned out to be very interesting and I had fun using it to design and build my robot. Using techniques for movement found in nature proved to more difficult than it initially seemed. Before this project, I always considered nature and man made machines to be two completely different ideas, but through the bio inspired process I have seen that, although still difficult, it is possible to construct man made machines that behave the same way as animals and insects in nature.

For the most part, the robot performed as expected. There was, however, a minor problem with its ability to walk in a straight line. It tended to turn slightly when the floor was uneven or some parts were more rough than others. This could be fixed by adding feet with better traction, such as rubber. The servos were also not completely accurate in their positioning, so the initial positions could have been a fraction of a degree different from each other, causing the robot to walk crooked over time.

VI. Conclusions

Although this project seemed very difficult at first, the final product was very successful in walking autonomously 4.9m across the track and back. The bio inspired design process began with brainstorming movement techniques found in nature to use as inspiration for the movement of the robot. Once those were determined, the sketches for the designs were drawn along with Hildebrand Gait plots and convex contact polygons to ensure stability. The best design was then chosen with the use of a Pugh chart. Once the design was approved by Prof. Spenko, it was ready for assembly.

The assembly went smoothly until it was determined that the ⅛" MDF was too weak to be used for the legs. The design for the legs was redone with ¼" MDF, which proved to be much stronger. Once constructed with the new design, the robot maneuvered the test track very well and was successful in meeting the functional requirement.

PARTS LIST			
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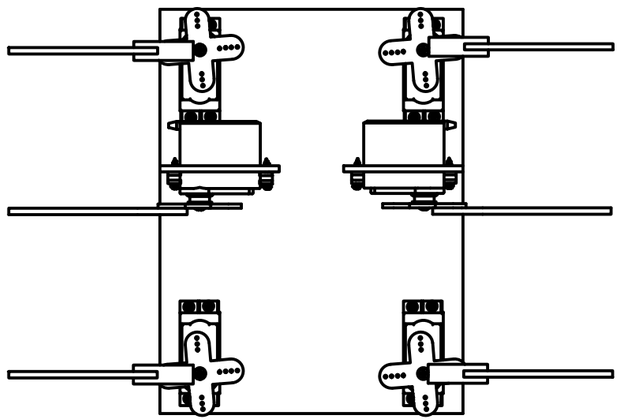
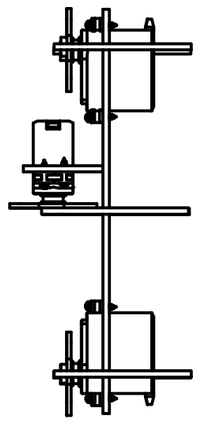
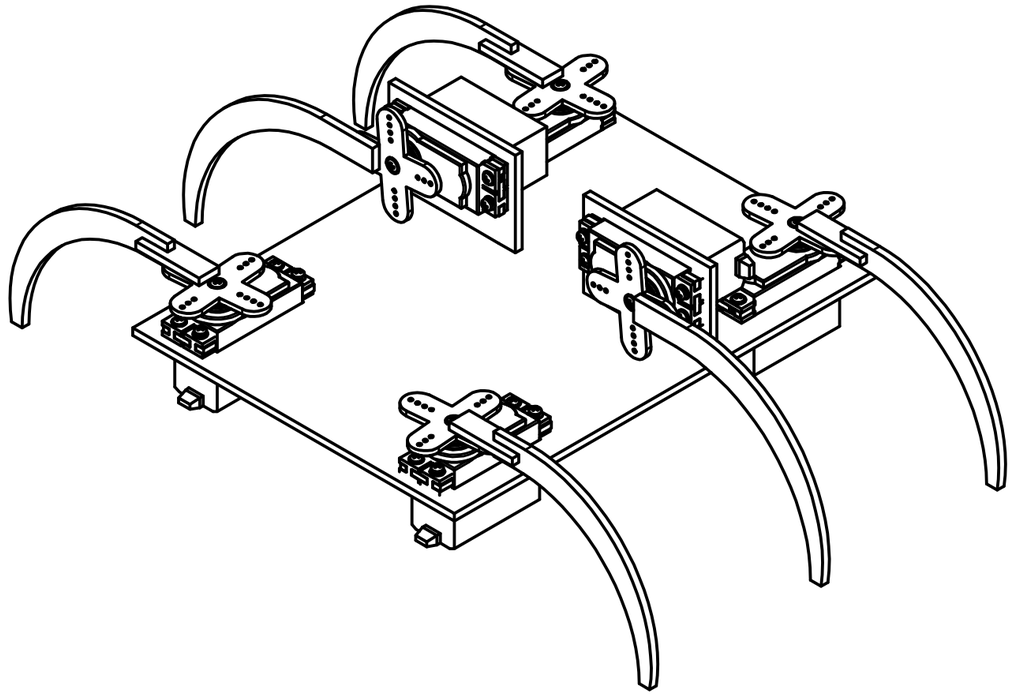
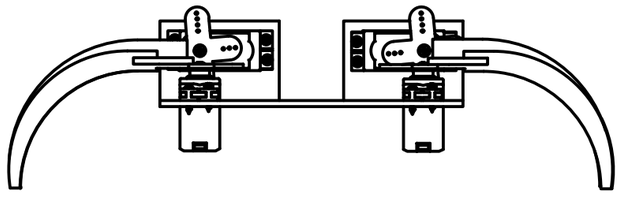
3	6	Servo Assembly	
4	6	leg	
5	4	legMount	









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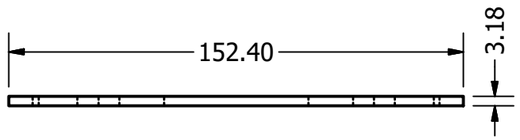

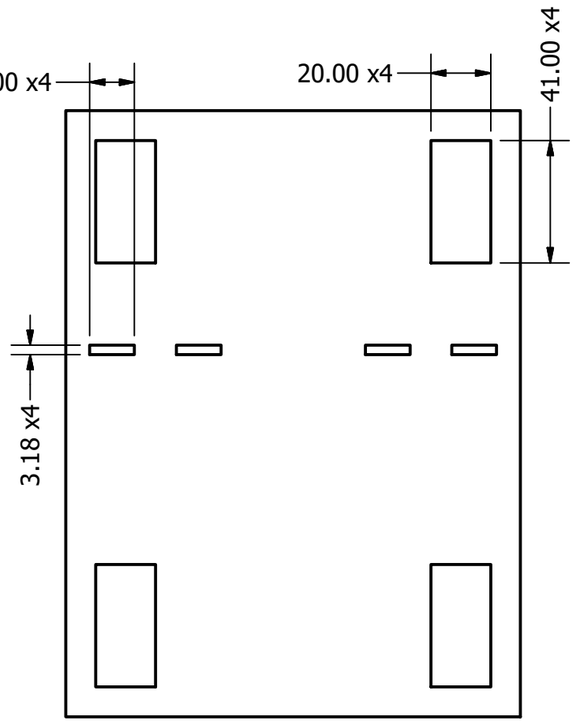

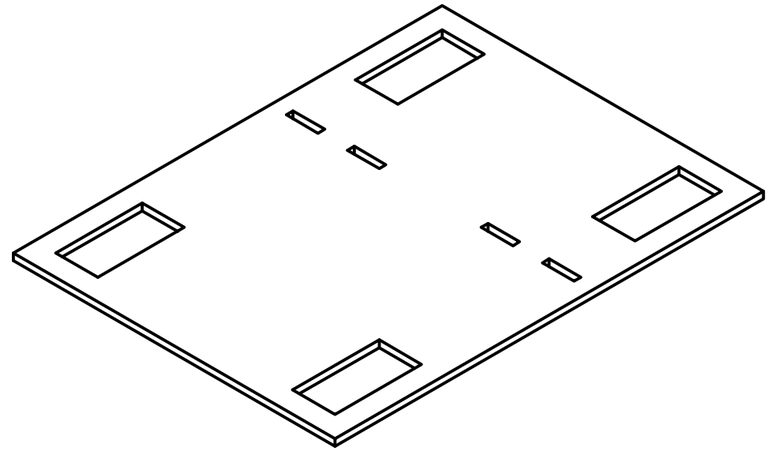

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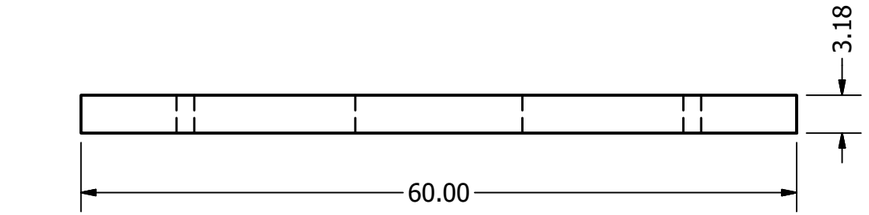

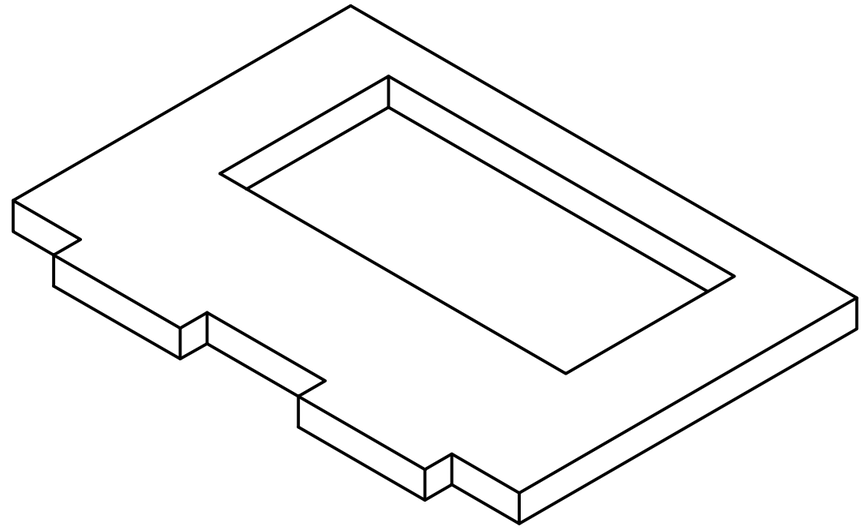

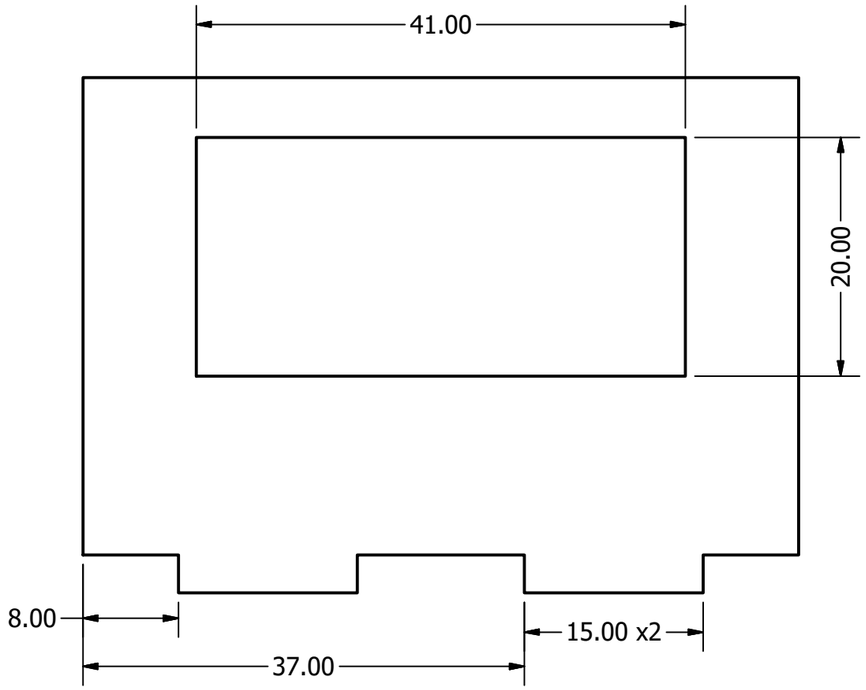

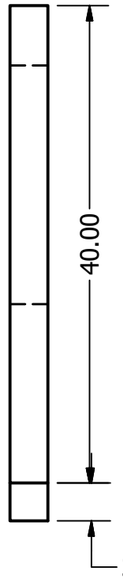

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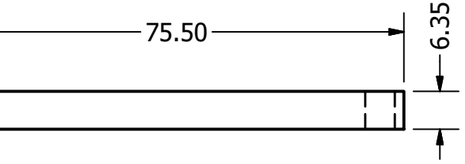

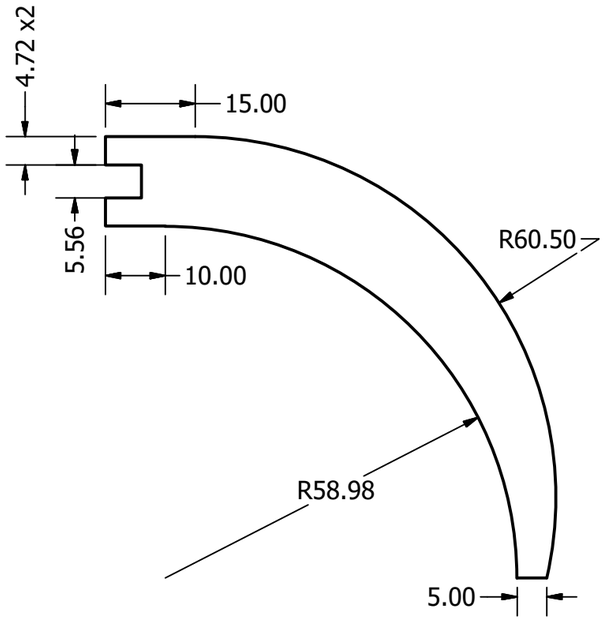

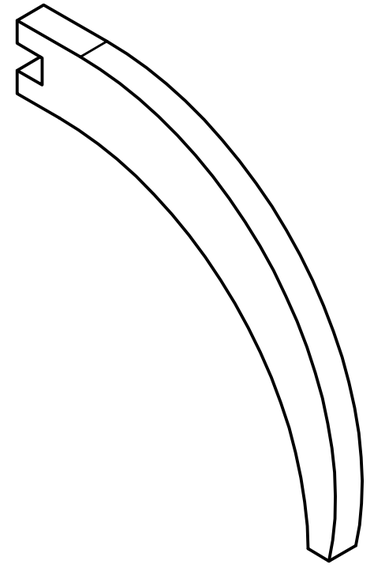

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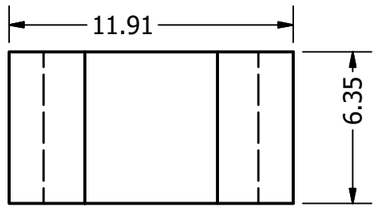

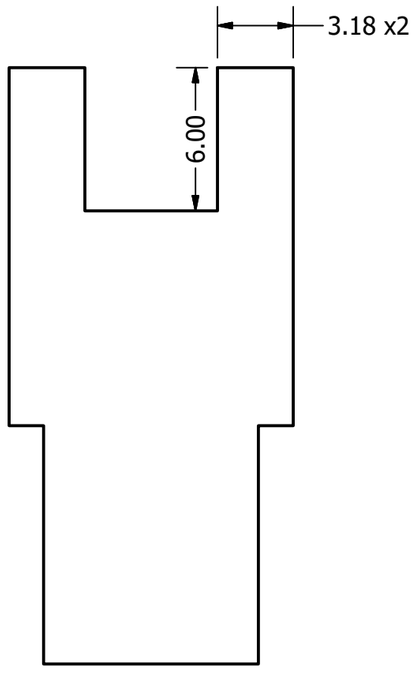

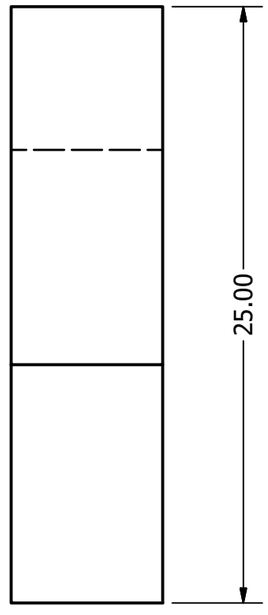

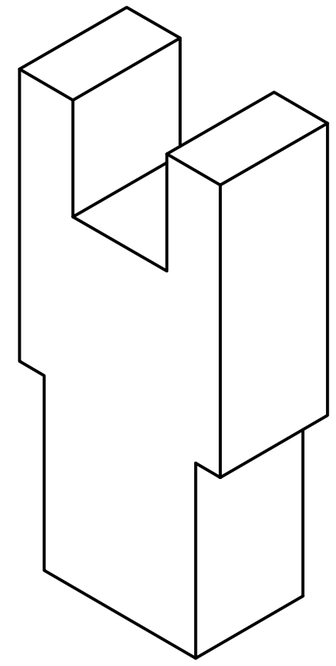

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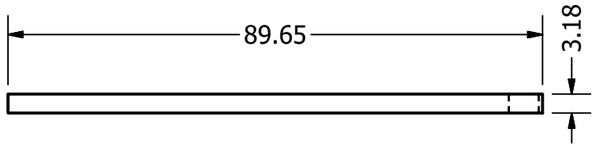

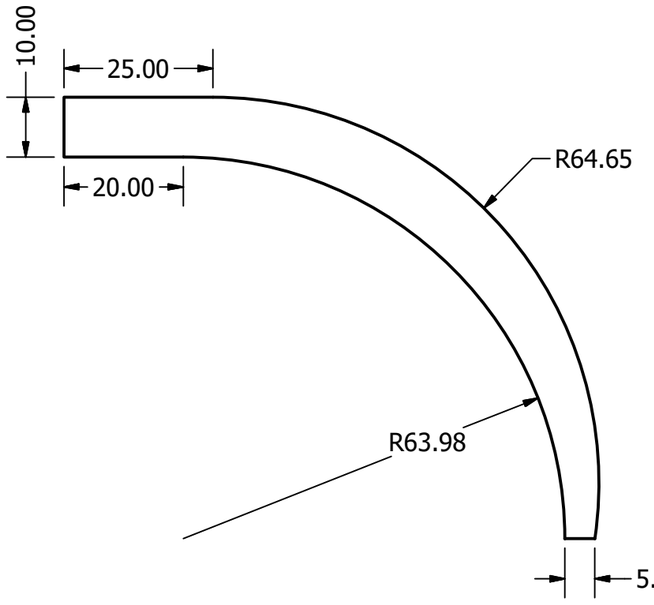

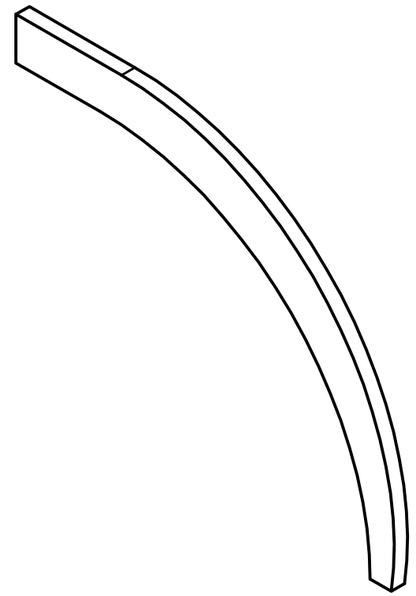

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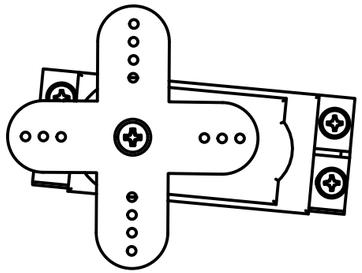

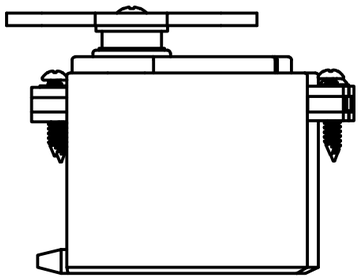

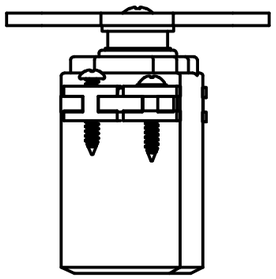

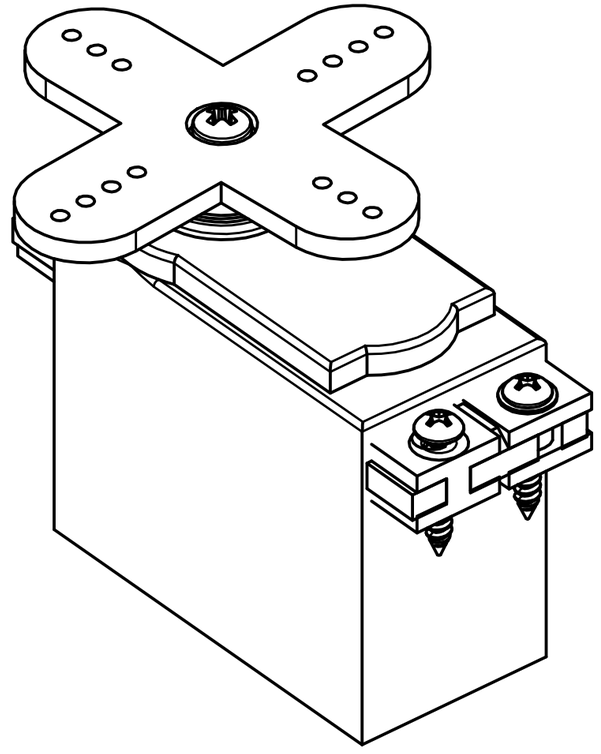

PARTS LIST			
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3	1	Standard Servo Horn- Red	
4	4	Standard Servo Rubber Grommet	
5	4	90184A064_316SS PAN HEAD PHILLIPS SCREW FOR SHEET METAL	
7	1	95836A255_METRIC PAN HEAD PHILLIPS MACHINE SCREW	

DRAWN Mateusz Rychtarczyk	11/15/2016	
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